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ABSTRACT

The Manufacturing Education Curriculum Project's feasibility study concerned with industrial arts curriculum development in manufacturing for the senior high school level is described. The need for an industrial arts curriculum which meets and reflects present and future trends is discussed in the introduction, followed by a review of the organizational process and a listing of the objectives developed to facilitate the proposed project. Both the sources and the rationale which accompanied the curricular research and technological research are examined, resulting in the identification of 11 trends in the manufacturing process. Six courses, developed from a review of curriculum guidelines (based on research by educational theorists and technologists), project research, and proposed directions, are listed and described. These courses include (1) Introduction to Manufacturing Systems, (2) Metal and Non-Metal Processing, (3) Graphic Communication Material-Processing, (4) Producing and Servicing Electro/Mechanical Products, (5) Producing and Servicing Electrical/Electronic Products, and (6) Contemporary Manufacturing Problems. Parameters and Constraints Affecting the Course, Course Descriptions (including Organization, Management, and Evaluation Needs), and an outline of the conclusions based on project research are included. (TM)

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MANUFACTURING EDUCATION CURRICULUM PROJECT

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Preface

During the past six years, two innovative junior high school industrial arts courses, developed by the Industrial Arts Curriculum Project (IACP), have attained widespread adoption in schools throughout the nation and overseas. Known as "The World of Construction" and "The World of Manufacturing," these courses provide junior high school boys and girls with a comprehensive overview and an activity-centered study of the man-made world. Strong support by students, parents, teachers, school administrators, and members of the industrial community attest to their value and success.

Success of IACP nurtured an interest for further development of innovative industrial arts curriculum materials for senior high school. At this level students would study, in greater detail, many of the technologies surveyed at the junior high school. This has been accomplished through two curriculum feasibility studies which have been completed. First, the "Construction Education Curriculum Project" (CECP), was conducted at The Ohio State University during the 1973-1974 school year and reported at last year's conference. Second, the Manufacturing Education Curriculum Project (MECP), an innovative industrial arts curriculum in manufacturing for the senior high school conducted during the 1974-75 school year, is being presented at this time.

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Introduction

All citizens in the United States have received an infinite number of benefits from the products created within our industrial enterprise system. Most of these products have been made to meet peoples' needs to improve their life-styles in an industrialized society. The machinery to maintain the standard of living functions quite efficiently, but:

> ...the social thinking, through which we may apply our developed capacities in humanly desirable terms, is less than adequate (McHale, 1969, p. 12).

There is a great need for all people, especially youth, to become technically literate regardless of whether the individual regards himself as an advocate of a humanistic or technical culture. Everyone must be aware of the improvement in our quality of life, the means by which our consumer needs are met, and many other achievements attributable to the advancement of manufacturing technology.

The nation's educational system has an obligation to provide the means by which students will develop the necessary skills, knowledge, and attitudes to cope with the man-made world. A study of manufacturing practices should help all youth make more intelligent decisions about careers, consumerism, the environment, and other societal problems created by technological advancement with which they are confronted.

One approach to solving the problems of education in the man-made world is suggested by Toffler:

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> The curriculum of tomorrow must thus include not only an extremely wide range of data-oriented courses, but a strong emphasis on future-relevant behavioral skills. It must combine a variety of factual content with universal training in what might be termed "life know-how." It must find ways to do both at the same time, transmitting one in circumstances or environments that produce the other (Toffler, 1970, p. 418).

An innovative high school industrial technology program would seem to make a viable contribution toward meeting these curriculum goals.

The Problem

Assuming that a study of "The World of Manufacturing" is an adequate introduction to manufacturing technology for eighth or ninth-grade students, what educational experiences should be planned to provide senior high school youth with extended and more specialized knowledge of manufacturing? What should be the scope and sequence of manufacturing technology courses at the high school level which will satisfy the needs of all students? These were the questions that the research and development team needed to answer with the guidance of an advisory committee consisting of representatives of various manufacturing management and labor organizations as well as professors from several universities involved in manufacturing education. (This group met with the R&D team in the fall to make recommendations about the project. They met again in the spring to review draft copies on the feasibility study document and make suggestions for revisions.)

The Project

The MECP began by establishing a set of objectives. They were to:

1. outline a pattern of program elements for the high school level which extend the student's attitudes, knowledge, and skills regarding industrial technology,

2. Conceptualize and create draft syllabi for those manufacturing program elements (courses) within this pattern,

3. determine effective and desirable instructional strategies and tactics for the proposed manufacturing program elements, and

4. provide a model for a full-scale research and development effort which would create, field-test, evaluate, and revise the required instructional systems in manufacturing education as well as establish plans for teacher preparation and dissemination activities.

Curricular Research

A review of literature and a survey of state departments of education provided documentation of existing instructional materials. Several of the institutional projects from the 1960's and early 70's provided some input as well as courses of study, guidelines, et cetera, which have been developed within various states for dissemination to teachers. Some chronological analysis provided insights into trends in manufacturing technology curricula beginning with the industrial revolution, through manual training, manual arts, industrial arts and into industrial technology. These have evolved into such programs as The Alberta Plan, Minnesota Plan, Activities of Industry, American Industry Project, Richmond Plan, Career Education in Manufacturing, and numerous others. The influences of Dewey, Richards, Bonser, Warner, Olson, DeVore, Yoho, and Maley are noteworthy.

Technological Research

The review of literature concerning trends in management, production, and personnel practices provided insights into the current and projected problems which will have a definite impact on industrial organizations and and our life-styles. Some of the basic needs of the manufacturing industry related to increased productivity, increased versatility, increased precision and reduction of job monotony (Melhope, 1975, p. 1). These are all being influenced by automation especially as controlled by computers. Our former "buy, use, discard" life-style may very well be replaced by the attitude by "buy, use, maintain, and recycle" as natural resources dwindle. A whole new field of "Secondary Industries may emerge in the technology of recycling. As corporations become multi-national conglomerates we will find our status as a leader in world trade being challenged by the imposition of the SI System of metric measurement. All of this will have a great impact on us as consumers and we need to be literate on these matters.

The government is having its influence on the manufacturing industry. Legislation has been enacted or pending to deal with many problems from a safe and healthy work place, to environmental protection, and consumer considerations.

The computer, mentioned previously, may be one of the major factors in developing a post-industrial society. If not, it is certainly redesigning the labor force from blue collar to white collar personnel. (In Japan a concept of Methodology of Unmanned Manufacturing (MUM) would convert a factory which has employed 700 to 800 workers in the past, to one needing only a small force of about ten "control people" (Merchant, 1975, p. 2). The relative cost of labor to productivity is forcing this drastic action.

The list of topics which could be covered is endless but there is one critical issue and that is the American way of life is being severely challenged to maintain its status in the world's society. We are confronted with many serious internal and external pressures dealing with the capability of our nation's manufacturing industry to sustain itself.

There are many trends to be considered as the manufacturing segments of our economic institution evolve. To summarize, some are the need to:

1. Extend the continuum of manufacturing organization from local proprietorship through national corporations, into multi-national conglomerates.

2. Pursue a commitment to protect the environment by reducing waste through recovery and remanufacturing by secondary industries.

3. Become more efficient users of current energy producing practices and/or develop alternatives for those practices.

4. Comply with industrial and governmental regulations to make this nation a safer and healthier place to live.

5. Proceed with plans to convert to the world system of metric measurement (probably SI) to remain competitive in world trade.

6. Provide consumers with information that will extend the life-cycle of the products they purchase.

7. Develop new technologies in automation which reduce the number of jobs deemed boring by workers.

8. Design new cost-reducing tools for management to apply to production practices which improve the quality and reliability of goods produced.

9. Organize the work place to accommodate variations of work scheduling and working conditions to increase worker satisfaction.

10. Continue R&D efforts to produce better goods at lower costs.

11. Anticipate a 1.4% to 10.3% annual growth rate through 1980 for manufacturers of goods utilizing industrial arts related materials. (U. S. Department of Commerce, 1974).

Instructional Strategies Research

The question for the educator as to how to communicate this information is awesome. Is there any area--be it general education, career education, vocational education, or whatever, that can create the necessary awareness? Hopefully, we will not continue to lag further and further behind in seeking answers.

In an effort to communicate manufacturing technology in the high school, criteria for curriculum development were studied. Based on research by various educational theorists and technologists, recommendations were made to prepare guidelines and directions in the following areas:

1. Overall guidelines for development of discipline-centered curriculum
2. Objective appropriateness guidelines
3. Psychomotor development guidelines
4. Cognitive development guidelines
5. Motivational guidelines
6. Social development guidelines
7. Characteristics of teachers (descriptions)
8. Characteristics of instructional materials (descriptions)

The strategy would be for the course developer to use these guidelines as he creates a teachers guide, laboratory manual, textbook, instructional hardware and instructional software for each of the semester-length courses outlined.

Course Offerings

Subject matter for the courses is based upon a rationale which provided: (1) a needs assessment, (2) background information on technological educational systems, and (3) current practices and projected trends for manufacturing and education. Each of the proposed courses for MECP will be outlined according to the following course titles:

1. Introduction to Manufacturing Systems
2. Metal and Non-Metal Material Processing
3. Graphic Communication Material Processing
4. Producing and Servicing Electrical/Electronic Products
5. Producing and Servicing Electro/Mechanical Products
6. Contemporary Manufacturing Problems

These courses are designed to develop an understanding of the manufacturing enterprise system. Parameters and constraints affecting the projected courses are identified as follows:

1. Products and practices of the man-made world affect the lives of everyone.

2. Life-styles of everyone have changed as a result of progress in manufacturing and construction technologies.

3. Technological advancement in manufacturing should be studied by high school age youth to assist them in making decisions about:

   3.1 Understanding the technologies of the manufacturing system.
   3.2 Becoming informed consumers of manufactured goods and services.
   3.3 Protecting the environment.
   3.4 Choosing careers.

4. A curriculum can be designed for senior high school youth as a sequel to the junior high school course, "World of Manufacturing." This prerequisite is not mandatory but should be encouraged.

5. Modern high school industrial arts facilities should be adaptable for this curriculum without extensive renovation or expenditures for equipment.

6. Instructional activities can be designed so that the concepts of manufacturing technology are presented within each course. However, a given concept receiving only a superficial comment in one course may become the focus of activities in another.

To illustrate the proposed courses the following descriptions are provided:

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Course #1. Introduction to Manufacturing Systems

The Introduction to Manufacturing Systems course is organized so that the students participate in activities of the manufacturing industry related primarily to the R&D phase of management technology. The focus of the course will be on those planning, organizing, and controlling pre-production practices which are vital to the productivity of a manufacturing enterprise. This course is most easily adapted to the drawing and design facility.

Course #2. Metal and Non-Metal Material Processing

Following the pre-production activities, the sequence of events in the manufacturing system continues from the mock-up stage, through management approval and prototype development, and ends with finished products. The material processing course begins with management approval and provides experiences in working with metal, wood, plastic, clay, and glass. By the end of the course students will have custom-produced and team-produced various components and finished products. The student should learn about preparing to produce (what materials, supplies, etc., to use) and production (separating, forming, combining).

Course #3. Graphic Communication Material Processing

Graphic communications, or graphic arts as it is called traditionally, involves relatively few processing concepts of production technology. However, it is an extremely important manufacturing industry because it provides printed products to other industries and to the individual consumer.

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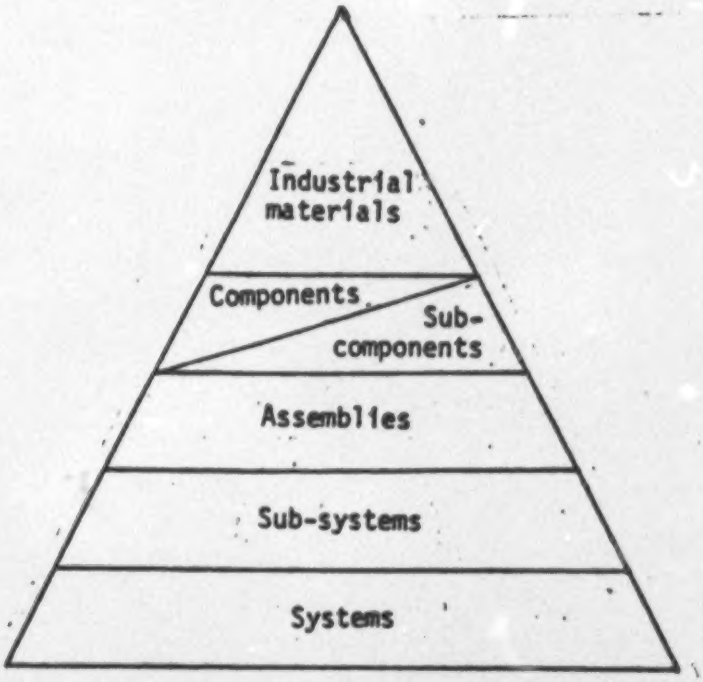
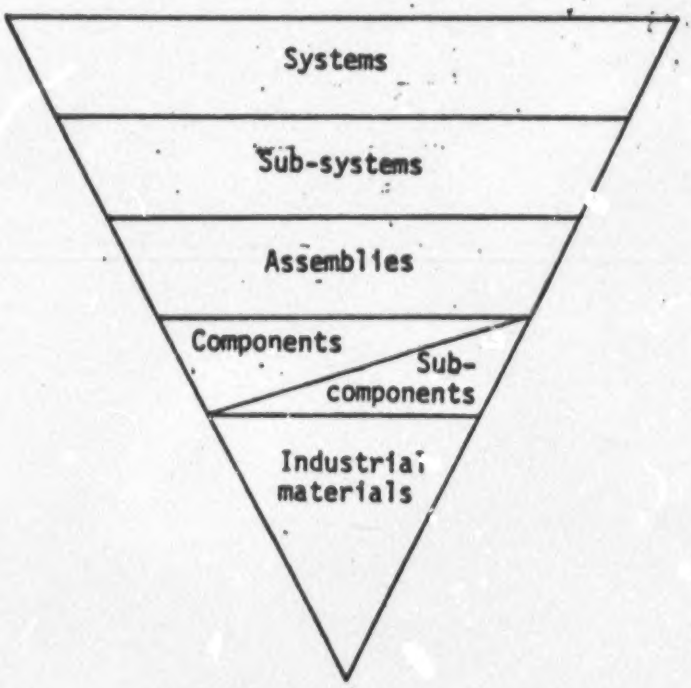
As in the previous course, the knowledge is pre-production and production oriented as it deals with screen processing, relief printing, continuous tone photographic processing, planographic processing, office duplicating, gravure processing, and binding. Related secondary industries are also discussed.

The next two courses deal with the manufacturing systems and servicing systems. They combine the concepts of processing with post-processing. Processing includes separating, forming, and combining and post-processing entails installing,maintaining, repairing, and altering. A commonality is illustrated in the following models for these two concepts. First, in the Manufacturing Systems Model, industrial materials are processed until they form the system to meet man's needs (automobiles, appliances, et cetera).



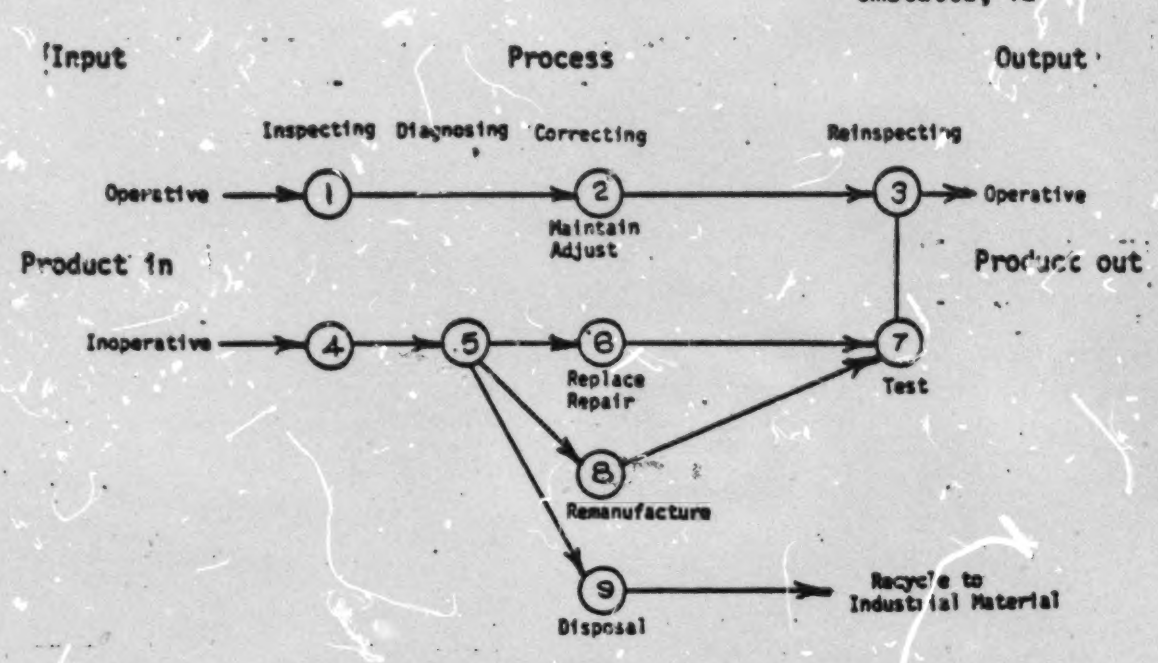
Manufacturing Systems Model

The Servicing Systems Model begins with the system which needs installation, maintenance, repair or alterations and troubleshoots, repairs, and tests products so they become functional again. This cycle would stop at the component level however, because that is the smallest part which is readily available.



Servicing Systems Model

As far as servicing a product is concerned, the Input-Process-Output system of manufacturing is appropriate:



Product Servicing Model

These three models are applied to both courses #4 and #5 to direct the learning activities.

Course #4. Producing and Servicing Electrical/Electronic Products

Through a sequence of laboratory activities, the students will learn about electrical products which produce light, heat, and motion from electrical energy during the first part of the course. They will explore the electronic concepts of conducting, converting, oscillating, amplifying, and switching (Inaba, 1970) during the remainder of the semester.

Course #5. Producing and Servicing Electro/Mechanical Products

This course utilizes the manufacturing and servicing systems models as they will direct the students' learning activities as they deal with (1) electrical input-mechanical output, (2) mechanical input-mechanical output, (3) mechanical input-electrical output, and (4) combinations of the above systems. The sequence of laboratory activities will

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provide students with an opportunity to learn about electrical, mechancial, fluidic, and pneumatic products, how they operate, and how to repair them. Many references will be made to the products which provide automation in the manufacturing industry.

Course #6. Contemporary Manufacturing Problems

The preceding courses have sampled the activities involved in meeting the wants and needs of people through the production of manufactured goods and the principles of servicing those goods to maintain their optimal operating efficiency. This course is designed to provide an opportunity for students to seek additional in-depth knowledge about a previous activity or to pursue new topics. It should probably not be taken before the third semester, which suggests that the student needs knowledge from the introductory and materials processing courses as a prerequisite.

A contemporary problems course should be one that guides the self-motivated student through the steps of the scientific method of problem-solving. As a result, the roles of manufacturing education instructors, and possibly of teachers from other academic disciplines in secondary education, will be that of resource personnel. Their responsibilities will be to guide the students in a problem-centered approach to learning.

There are some common topics for all kinds of manufacturing systems revealed in the review of literature which should be included to varying degrees in all courses. They deal with: (1) process planning, (2) material selecting and testing, (3) production planning, (4) tooling

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up for production, (5) plant layout, (6) quality assurance, (7) plant engineering, (8) manufacturing management, (9) manufacturing systems, (10) consumer satisfaction, (11) metrology, and (12) automation. Problems that deal with personnel technology and the industrial organization are also common and provide career awareness, orientation, and exploration.

Organization, Management, and Evaluation

To accomplish the goals of this MECP feasibility study, a dedicated group of people with well defined responsibilities will be needed. The plan is to have a headquarters staff and several curriculum development centers. Each center will prepare all essential instructional materials for a course or courses and forward them to the headquarters where they will be compiled in draft form for distribution to previously identified field-test centers. Following this cycle the material will be revised and published.

Various forms of formative and summative evaluation strategies will be incorporated to maintain validity and keep the project on schedule as well as provide data for the final report.

It is anticipated that some form of teacher-education will be needed during the field-test phase and when the courses are implemented by others. This will be controlled in a manner similar to the IACP.

Conclusions

The MECP staff has examined the present state of secondary education in the United States and has reached the following conclusions about potential manufacturing curriculum proposals:

1. There exists a definite need for a discipline-centered curriculum in industrial arts at the senior high school level.

2. This curriculum should be based on a system of discrete semester-length courses.

3. These courses should reflect contemporary practices as they apply to manufacturing technology.

4. These courses should center around the following areas:

   4.1 Introduction to Manufacturing Systems
   4.2 Metal and Non-Metal Material Processing
   4.3 Graphic Communication Material Processing
   4.4 Producing and Servicing Electrical/Electronic Products
   4.5 Producing and Servicing Electro/Mechanical Products
   4.6 Contemporary Manufacturing Problems

5. The development of the specific courses should be done with adequate and diversified inputs of staff and resources. This suggests that the development take place at several institutions of higher education where educational and technical expertise is available.

6. These courses must be developed in such a manner that present senior high school industrial arts teachers can implement them after appropriate orientation.

7. A three-year developmental sequence will be needed to efficiently produce the tested and refined instructional system.

This curriculum as researched by MECP could greatly enhance the academic status of industrial arts education.

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